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Growth performance of goats (*Capra hircus* L.) on forage legumes mixed with guinea grass (*Megathyrsus maximus*)

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Proper feed optimization is vital for the health and growth of goats, with fodder quality being a central factor. This study evaluated the impact of feeding goats guinea grass mixed with various tree legumes on their growth and feed consumption. Nine upgraded goats were used for this research, divided equally among three treatment groups. Each treatment was repeated three times, with one goat per repetition. The experimental treatments included guinea grass paired with Gliricidia (T1), Indigofera (T2), or Ipil-ipil (T3). The results showed that the T2 (Guinea grass + *Indigofera tinctoria*) combination resulted in the highest feed intake at 29.94kg over five weeks, a finding significant with a p-value of 0.04. Nutrient analysis demonstrated a significant intake of crude protein for T2 with a p-value of 0.038. Moreover, T2 exhibited the most substantial total weight gain (3016.67g) and an average daily gain of 86.19g/day, with p-values of <0.001 and 0.013 respectively. In conclusion, the mix of Guinea grass and I*ndigofera tinctor*ia offers the best results in terms of feed intake and goat growth performance.
Keywords: Goat feed optimization, guinea grass, Indigofera, Gliricidia, Leucaena.

INTRODUCTION

Goat farming is a vital agricultural activity that spans various regions, offering livelihoods to millions worldwide. Beyond its substantial contribution to meat, milk, and fiber production (Lohani and Bandari, 2021), goats also uphold the ecological balance within certain farming systems (Paramesh *et al.*, 2022). Central to the sustainability and profitability of goat farming is the proper optimization of feed intake and subsequent growth performance. At the core of this optimization is quality fodder, which directly impacts these factors, setting the benchmark for the animals' overall health and productivity (Akakpo *et al.*, 2022).

Originally from Africa's tropical regions, Guinea Grass has garnered global favor among farmers due to its adaptability and resilient growth in various climates (FAO., 2009). Its nutritional profile boasts commendable carbohydrate levels complemented by a notable protein count, making it a potent energy source for livestock (Benabderrahim and Elfalleh, 2021).

In tandem, foraging legumes have evolved in symbiosis with nitrogen-fixing bacteria, rendering them a pivotal source of protein-rich fodder for livestock (Smýkal *et al.*,2014). They stand out with their high protein and micronutrient content, making them indispensable in livestock diets. While clover, alfalfa, and vetch have garnered attention, other legumes such as Gliricidia, Leucaena, and Indigofera have demonstrated potential to significantly influence livestock health and productivity in tropical settings. (Naheed *et al.*, 2023).

Building upon these insights, the combination of grasses and legumes is not merely a traditional feeding practice but a scientifically backed approach to achieve balanced nutrition (Wróbel *et al.*, 2023). The inherent synergy between grasses and legumes offers a comprehensive nutrient mix that can amplify both feed intake and growth (Quintero-Anzuela *et al.*, 2021). Past research solidifies this premise, highlighting how traditional practices often prioritize such feed combinations (Ajayi *et al.*, 2021; Phimphachanhvongsod and Ledin, 2002; Richards *et al.*, 1994; Uemura, 2014).

Despite these findings, a significant research gap exists regarding the benefits of supplementing tree legume species namely Leucaena (*Leucaena leucocephala*), Indigofera (Indigofera tinctoria) and Gliricidia (*Gliricidia sepium*) with Guinea grass (*Megathyrsus maximus*). The study aims to evaluate the impact of feeding guinea grass combined with various tree legume species on the feed intake of growing goats and to ascertain the growth performance outcomes from these dietary combinations. It is hypothesize that the

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combination of Guinea grass with diverse tree legume species will significantly improve both the feed intake and growth performance of growing goats, offering an optimized fodder approach for sustainable goat farming.

MATERIALS AND METHODS

***Ethical consideration*:** The study adhered to the guidelines stipulated in R.A. 8485, the Animal Welfare Act of the Philippines.

***Location and Duration*:** The research was conducted in the goat house located within the College of Agriculture, Forestry, and Environmental Sciences at MSU Naawan. The feeding experiment lasted for 35 days (5 weeks), providing in-depth insights into the goats' dietary patterns and preferences.

***Experimental Animals*:** Nine crossbred growing goats, a combination of native goats and purebred Anglo-Nubian meant for meat production, were selected. Each goat was approximately 2 months old, with initial weights ranging between 9.5kg and 13.1kg.They were housed in an elevated, gable open-sided shelter made of lightweight materials. Before the experiment commenced, all the animals received treatments: they were dewormed with Ivermectin (administered at a dosage of 5ml per 50kg live weight) via subcutaneous injection, and were given iron (Dextran 20% + B12) and vitamins (Vitamin ADE) through intramuscular injections. The goats underwent a 7-day acclimatization period before the onset of the study.

***Experimental treatments*:** The experiment incorporated tree legumes mixed with Guinea grass as part of the dietary treatments. The specific treatments were:

T1 = Guinea grass + Gliricidia (*Gliricidia sepium*)
T2 = Guinea grass + Indigofera (*Indigofera tinctoria*)
T3 = Guinea grass + Leucaena (*Leucaena leucocephala*)

Using a Completely Randomized Design (CRD), nine (9) growing goats were evenly distributed across the three (3) treatments. Each treatment was replicated three (3) times, with one (1) goat assigned to each replication. To allocate the goats randomly to the treatments, a "draw lots" method was used, ensuring an unbiased assignment.

Table 1. Proximate analysis of guinea grass, legume forages, and concentrate diet.

Nutrient content (%)	Guinea	Gliricidia	Indigofera	Leucaena	Concentrate feed
DM, %[1]	27.60	23.5	21.4	26.76	95.11
CP, %[2]	13.60	22.6	23.5	23.30	16.34

[1]As fed basis; [2]Dry Matter basis

Throughout the study, the experimental animals were fed a diet that consisted of 30% concentrate and 70% roughage. The roughage was made up of 70% Guinea grass (*Megathyrsus maximus*) and 30% tree legumes, which included Gliricidia (*Gliricidia sepium*), Indigofera (*Indigofera tinctoria*), and Leucaena (*Leucaena leucocephala*). Furthermore, the concentrate portion of the diet comprised corn grits, Rice Bran D1, soybean meal, and salt. The diet was formulated based on the goats' daily dry matter intake needs, which amount to 3% of their body weight. The proximate analysis for the guinea grass, legume forages, and concentrate is presented in Table 1, while the details for the experimental diets can be found in Table 2.

Table 2. Proximate analysis of experimental diets.

Nutrient Content (%)	T1	T2	T3
DM, %	26.37	25.74	27.35
CP, %	16.30	16.37	16.51

[1]As fed basis; [2] Dry Matter basis
T1 Guinea grass + Gliricidia sepium; T2- Guinea grass + Indigofera tinctoria; T3= Guinea grass + Leucaena leucoephala

Guinea grass was harvested every morning and chopped to a length of 6-7 cm using a chopper before being fed fresh in the trials. The Gliricidia, Indigofera, and Leucaena were also harvested in the morning, with only the young leaves and soft stalks used and fed fresh for the experiment. Feeds were provided twice a day, at 08:00 am and 03:00 pm, with half of the daily ration distributed at each feeding. The feed quantities were weighed daily and adjusted based on individual animal body weights.

***Data gathered*:** Feed samples were analyzed in the Analytical Laboratory at the College of Agriculture, Forestry, and Environmental Sciences to determine their dry matter (DM) and crude protein (CP) contents.

Feed Intake (FI) is determined by the difference between the amount of feed provided and the feed that the goat rejected.

$$FI = (Feed\ Given - Feed\ Refused)$$

Nutrient Intake was quantified by considering both the total feed consumed by the goat and the total feed it rejected. It can be calculated using the following equation:

Nutrient intake (g) = [(Feed given x % nutrient of given)-(feed refused x % of nutrient refused)]

Whereas the nutrients were: DM and CP

Nutrient Intake (as %body weight) takes into account the variation in body size that can influence feed intake:

$$\text{Nutrient, as \% BW} = \frac{\text{Nutrient intake(g)}}{\text{Initial weight}} \times 100$$

Feed Conversion Ratio (FCR) is the measure of the daily nutrient intake from the feed provided to the animal relative to its average daily gain:

$$\text{Feed Conversion Ratio (FCR)} = \frac{\text{Daily nutrient intake of feed given}}{\text{Average daily gain}}$$

Whereas the nutrients were: DM and CP

***Statistical analysis*:** Data gathered was analyzed using the Statistical Package for Social Science (SPSS) Version 25.0. The analysis of variance (ANOVA) was employed, and

treatment means were compared using Tukey's Honestly Significant Difference (HSD) Test at a 5% level of significance.

RESULTS AND DISCUSSION

***Feed Intake*:** Over the course of five weeks, the goats in T2 (Guinea grass + Indigofera tinctoria) consumed the most total feed with an intake of 29.94kg, which was statistically significant (p-value of 0.04) compared to T3 (Guinea grass + *Leucaena leucocephala*) with 27.31kg and closely followed by T1 (Guinea grass + *Gliricidia sepium*) with 28.7kg.
Notably, during the fourth and fifth weeks, the feed intake varied significantly between the treatments, with T2 consistently having higher intakes compared to T3, and T1 showing varied results between these weeks. The observed variations in feed intake might provide insights into the preferences or digestibility of the legumes over time.

Table 3. Feed intake of goats in kg fresh weight basis as influenced by feeding of various forage legumes with guinea grass.

Feed intake	T1	T2	T3	p-value
Week 1	5.34±0.72	5.12±0.61	5.89±1.12	0.23
Week 2	5.44±0.96	4.89±0.87	6.54±0.73	0.12
Week 3	6.12±1.30	6.33±0.45	5.33±0.67	0.09
Week 4	6.04±1.10^{a}	6.80±0.97^{a}	4.43±0.61^{b}	0.02
Week 5	5.76±0.45^{ab}	6.8±.55^{a}	5.12±0.56^{b}	0.04
Total feed intake	28.7^{ab}	29.94^{a}	27.31^{b}	0.04

T1- Guinea grass + Gliricidia sepium; T2- Guinea grass + Indigofera tinctoria; T3= Guinea grass + Leucaena leucocephala

The data from Table 3 suggests that goats most preferred the combination of Guinea grass and Indigofera tinctoria (T2), especially during the later weeks of the experiment. The findings align with those of Anis *et al*., 2020, which studied the use of dwarf elephant grass combined with various tree legumes. Among them, *Indigofera zollingeriana* showed superior growth performance compared to Leucaena and Gliricidia. On the other hand, the mix of Guinea grass and *Leucaena leucocephala* (T3) was less favored, notably in week 4. This observation aligns with the findings of (Dapar *et al.,* 2023), which indicated that a higher proportion of Leucaena in the diet led to reduced feed intake. A key factor behind this is the presence of mimosine, a non-protein amino acid found in leucaena. This compound can adversely affect animals, leading to issues such as alopecia, hindered growth, and thyroid gland complications (Yanuartono *et al.,* 2019). While certain ruminants possess gut microbes capable of breaking down mimosine, the dietary content and adaptation period can modulate its effects, thereby influencing feed intake (Derakhshani *et al.,* 2016). The notable differences observed in the later weeks might point to long-term palatability or digestibility issues affecting goat preferences. To ascertain the exact nutritional, anti-nutritional, or taste-related causes of these variances, further investigations are necessary.

***Nutrient intake*:** The uniformity in Dry Matter Intake (DMI) across the treatments implies that all forage legume combinations with guinea grass were comparably consumed by the goats in terms of dry matter. However, what stands out is the marginally higher protein intake in the T2 combination, pointing towards the potential superior protein content or palatability of the *Indigofera tinctoria* when paired with guinea grass. Some leguminous forages contain tannins, which can sometimes reduce palatability. However, the tannin content in *Indigofera tinctoria* is relatively moderate, ensuring that it doesn't impart a very bitter taste and remains acceptable to animals (Antari *et al.,* 2022). *Indigofera tinctoria* has a high leaf-to-stem ratio. Leafy forages are generally more palatable than stemmy ones, providing a softer texture and often higher nutritional value, hence making it more palatable (Kaitho *et al.,* 1996). This difference in the result is statistically significant, marking its relevance for potential dietary considerations.

Table 4. Nutrient intake of goats (*Capra hircus)* as influenced by feeding of various forage legumes with guinea grass.

Feed intake	T1	T2	T3	p-value
DMI (g/d)	216.2±23.43	220.2±34.56	213.4±43.12	0.221
CPI (g/d)	133.7±17.38	142.0±20.03	128.8±21.04	0.038
DMI (%, BW)	1.80±0.05	1.83±0.06	1.78±0.05	0.410
CPI (%, BW)	1.11±0.03	1.18±0.04	1.07±0.04	0.320

T1- Guinea grass + *Gliricidia sepium;* T2- Guinea grass + *Indigofera tinctoria*; T3= Guinea grass + *Leucaena leucocephala*

***Growth Performance*:** Table 5 showcases the growth performance of goats subjected to different dietary regimens. The most significant weight gains were observed in goats fed the combination of Guinea grass and Indigofera tinctoria (T2).

Table 5. Total weight gain (TWG), Average daily gain (ADG), and Feed Conversion Ratio (FCR) of goats (*Capra hircus)* as influenced by feeding of various forage legumes with guinea grass.

Feed Intake	T1	T2	T3	p-value
TWG, g	1990.0±512^{c}	3016.7±634^{a}	2544.4±589^{b}	<0.001
ADG, g	56.85±5.35^{b}	86.19±14.12^{a}	72.70±13.12^{a}	0.013
FCR, DM	3.80±.81	2.55±.52	2.93±.76	0.210
FCR, CP	2.35±.45	1.65±.08	1.77±.09	0.428

T1- Guinea grass + Gliricidia sepium; T2- Guinea grass + Indigofera tinctoria; T3= Guinea grass + Leucaena leucocephala

The lesser growth performance associated with *Leucaena leucocephala* is attributed to its content of mimosine, an anti-nutritional factor. When ingested in large amounts, mimosine

can hinder growth (Reis *et al.*,1975). Even though goats possess enzymes that can detoxify mimosine to a degree, its presence might still limit the growth benefits provided by Leucaena. Forages with enhanced digestibility generally lead to more efficient nutrient extraction and utilization (Niepes and Bestil, 2023). If *Indigofera tinctoria* boasts superior digestibility compared to Leucaena and Gliricidia, it could further boost its positive effects on weight gain and FCR. Indigofera is a nutritious tree legume that has high protein and TDN contents and has a potential to use for other ruminants such as cattle (Antari *et al.*,2022).

Additionally, the lesser growth performance observed in goats fed a combination of Guinea grass and Gliricidia could be due to Gliricidia's cell wall components. These might possess a structure less conducive to ruminal microbial digestion than other legumes, potentially diminishing nutrient availability for the animal (Paterson *et al.*,1999).

The Feed Conversion Ratio (FCR), which measures an animal's efficiency in converting feed into body weight, indicated a trend favoring the T2 combination in terms of both Dry Matter (DM) and Crude Protein (CP) intake. However, the differences weren't statistically significant across treatments. This implies that while the T2 combination resulted in more marked weight gains, the various mixtures were somewhat similar in their feed-to-mass conversion efficiency. The combination of *Indigofera tinctoria* and Guinea grass appears to offer a more harmonious nutrient profile, potentially providing an ideal balance of energy (from the grass) and protein (from the legume). This blend might be more conducive to growth than combinations of Guinea grass with Leucaena or Gliricidia. Nonetheless, additional research is needed to substantiate these claims.

Conclusion: The study revealed that a diet combining Guinea grass and *Indigofera tinctoria* led to an improved feed and nutrient consumption, particularly in crude protein, for goats. These goats showed the most pronounced weight gain and daily growth.

The findings from this study have practical implications for goat farmers. This means that by adopting this particular feed combination, farmers could potentially achieve better production outcomes, leading to increased profitability and sustainability of their goat farming operations. Considering the benefits observed, it is crucial to further investigate the optimal proportions of the feed combination, its long-term impact on goat health and productivity, and its scalability across varied farming environments.

***Authors' Contribution Statement*:** Mark Anthony T. Maña led and conducted the feeding trial, while Richelle A. Niepes was responsible for manuscript writing and analysis. Mechie Ann C. Florida and Rochelle A. Paculba performed the proximate analysis and assisted in polishing the output.

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